Electronics II

Lecture 02
Transistor Modeling as an Amplifier

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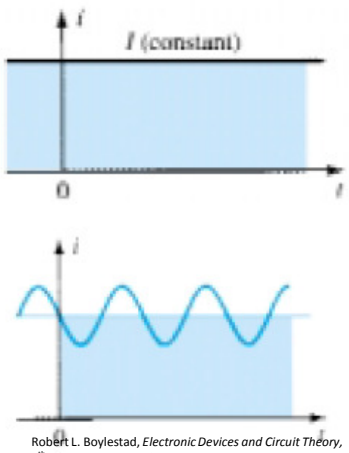
Session Overview

Topic	Transistor Modeling as an Amplifier
Concepts	Transistor Amplifying Action, Two Port Network and Parameters, Input Impedance, Output Impedance, Voltage Gain, Current Gain.
Recommended Reading	Sections 7.1 through 7.4 of [1]
Keywords	Amplifier, Input Impedance, Output Impedance, Current Gain, Voltage Gain, Phase Relationship.

Amplification in AC Domain

- Transistor can be used as an amplifier. Basic amplifying action is that the output AC power is greater than the input AC power.
- This increase in output power is achieved at the expense of DC power.
- Conversion Efficiency , η

  $\eta = P_{o\,(ac)} / P_{i\,(dc)}$

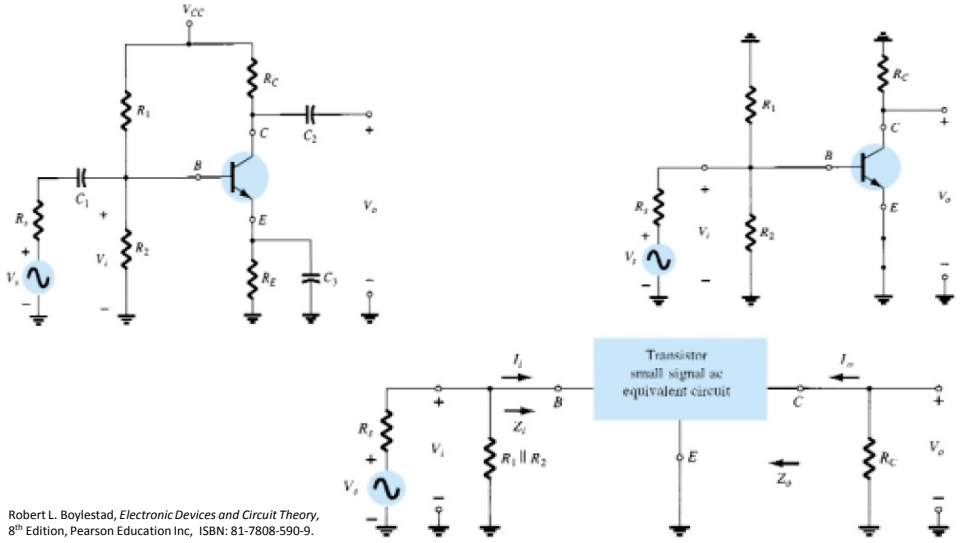


Robert L. Boylestad, *Electronic Devices and Circuit Theory*, 8th Edition, Pearson Education Inc, ISBN: 81-7808-590-9.

BJT Transistor Modeling

- The major step of small signal analysis is to determine the ac equivalent circuit of the device.
- This ac equivalent model replaces the schematic symbol within the circuit and the analysis is performed.
- There are two ac equivalent models – hybrid model and re model.
- Which one is suitable?
- For AC analysis, all the DC power supplies can be replaced by short circuit.
- All coupling and by- pass capacitors are assumed to have very small reactance at the frequency of interest, and they are replaced by low resistance paths/ short circuit.
- This will cause a by-pass/ short circuit for the emitter resistance R_E.

BJT Transistor Modeling



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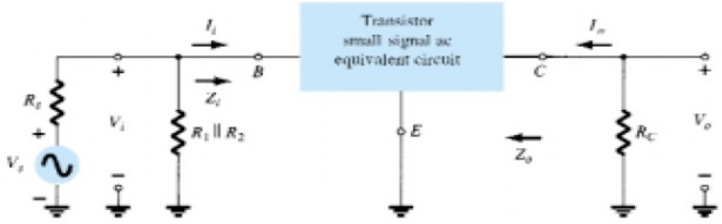
BJT Transistor Modeling



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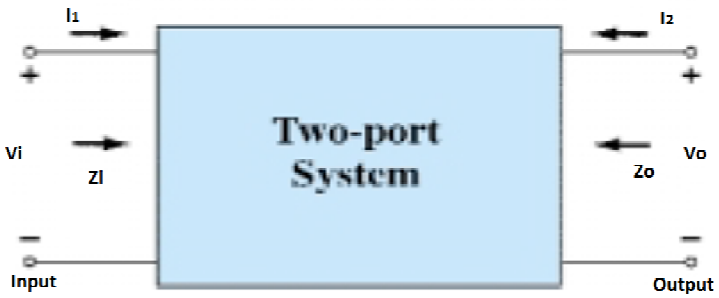
1. Set all dc sources to zero and replace these by short circuit equivalent.
2. Replace all capacitors by short circuit equivalent.
3. Remove all elements bypassed by the short circuit equivalents replaced as a result of steps 01 and 02.
4. Redraw the network in a more convenient way.

Important Parameters of Two Port Systems



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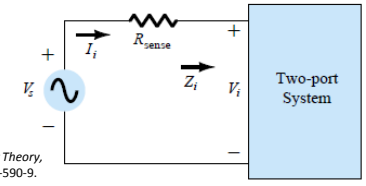
Input Impedance, Z_i

- Small signal AC input impedance Z_i can be calculated as
  $Z_i = V_i / I_i$.
- For small signal analysis, once Z_i is determined, same value can be used for the varying levels of input signals.
- Input impedance of a transistor can approximately be determined by DC biasing conditions.
- For frequencies in low to mid-range (typically ≤100KHz)
  - Z_i of BJT amplifier is purely resistive and vary from few Ohms to Mega- Ohms.
- An ohm-meter cannot be used to measure small signal ac input impedance.(Why?)



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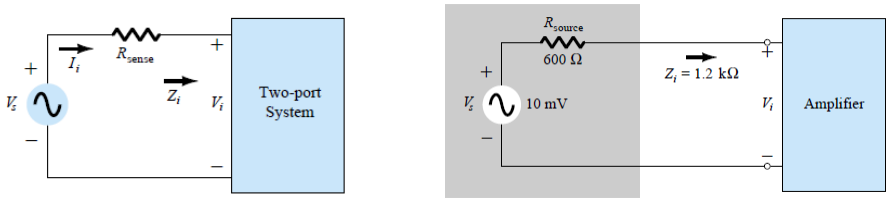
Input Impedance, Z_i

- Input impedance Z_i can be calculated as

  $I_i = (V_S - V_i)/ R_{sense}$.

  $Z_i = V_i / I_i$.

- Significance of input impedance



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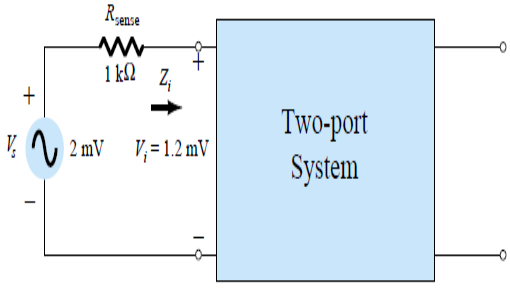
Input Impedance, Z_i

- Example 7.1 (Boylestad):

- Determine the Input impedance of the given two port system.



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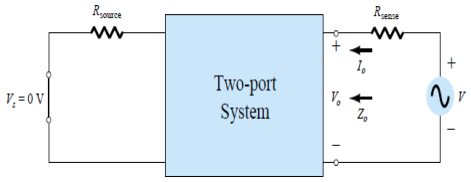
Output Impedance, Z_o

- The small signal AC impedance measured at the output terminals of a two port system is referred to as Output Impedance, Z_o.
- Z_o is determined by looking back into the output terminals and setting the applied signal to zero.
- $I_o = (V-V_o)/R_{sense}$.
- $Z_o = V_o/I_o$.
- For low to mid range frequencies (typically ≤100KHz) the output impedance of a BJT amplifier is resistive in nature.
- Z_o cannot be determined by Ohm-meter.



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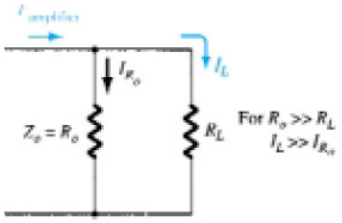
Output Impedance, Z_o

- For a significant current gain, Z_o should be much greater that the load resistance, R_L.
- Why?
- Example 7.2 (Boylestad): Determine Z_o.



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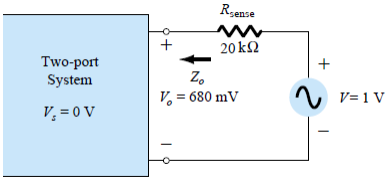

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References

[1] Robert L. Boylestad, *Electronic Devices and Circuit Theory,* 8th Edition, Pearson Education Inc, ISBN: 81-7808-590-9.